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Optical control of valley pseudospin in 2D semiconductors

Valley polarization associated with the occupancy in energy degenerate but quantum mechanically distinct valleys in the momentum space resembles spin polarization in many regards, including the valley magnetic moment, optical selection rule, and valley hall effect. Monolayer transition metal dichalcogenides (TMDs) with broken inversion symmetry can host robust valley polarization and therefore become an important platform for studying valley related physics. We demonstrated that the valley polarization in the TMD can not only be initialized and measured but also be manipulated coherently by light. [1] Ultrafast valley pseudospin rotation was achieved by leveraging the intense electric field in the fs laser pulse. Both the direction and speed of rotation can be controlled by fine-tuning the dynamic phase difference between the exciton wavefunction in opposite valleys. The pseudospin rotation was reflected in the shift of the photoluminescence polarization direction. By varying the time delay between the excitation and control pulses, we were able to directly probe the lifetime of the intervalley coherence in monolayer WSe2. In addition, I will discuss how the lifetime of TMD excitons can be significantly improved by the hexagonal boron nitride encapsulation, which allows us to observe both neutral and charged biexciton species with non-trivial spin-valley configurations. [2]

References

[1] Z. Ye, D. Sun, T. F. Heinz, Nature physics, 13 (2017) 26
[2] Z. Ye, et al., Nature communications, 9 (2018) 3718

Figures

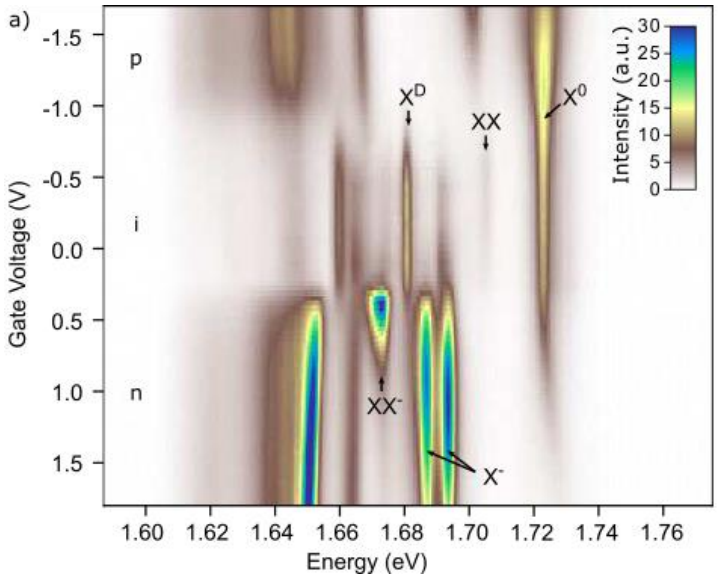

Figure 1: Photoluminescence spectra of a hBN encapsulated WSe_2 monolayer at different doping levels.